American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS)

ISSN (Print) 2313-4410, ISSN (Online) 2313-4402

http://asrjetsjournal.org/

Self-Compacting Concrete: Strength Evaluation of Corn Cob Ash in a Blended Portland Cement

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Abstract

The paper investigates the prospects of corn-cob ash (CCA) as effective constituent in self-compacting concrete. The structural value of the composite was evaluated with consideration for its suitability as self-compacting concrete. Varied percentage of corn-cob ash at 0%, 10%, 20%, and 30% replaced cement in a mix of 1:2:4 concrete with variable plasticizer admixture of COMPLASTSP430 at 0%, 1%, 2% and 3% replacement. Specified tests for Self-compacting concrete (SCC), related to workability such as flowability, filling-ability, and passing-ability tests were carried out on fresh samples. Compressive strength of hardened cured (150 x 150 x 150) mm concrete cubes at 7days and 28 days were tested. The results showed that at 2% SP430 and 30% CCA replacement, the compressive strength was 20.37N/mm^2, while the flowability, filling ability, passing ability, and segregation potential were 755mm, 29mm, 6 sec and 6.2mm respectively. On analysis and comparison of the results with known SCC standard, a percentage replacement of 2%SP430 and 30%CCA meet the requirement of self-compacting concrete.

Keywords*:* Corn-Cob Ash; Compressive strength; Plasticizer; Self-compacting concrete; Segregation potential.

1. Introduction

Cement concrete is the most widely used building material due to its satisfying performance in strength requirements and its ability to be moulded into a variety of shapes and sizes. Construction works globally is increasing at alarming rate with substantial consumption of cement in large proportion hence the need for full or partial replacement of cement.

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Self-compacting concrete (SCC) was first developed to increase concrete usage by engineers in Japan in the early 1980s with the introduction of conventional super-plasticizers to create highly fluid concrete, while also using viscosity-modifying admixtures (VMA), which increased plastic viscosity thus preventing segregation up to a level of fluidity that would normally cause segregation [8].

According to [7], SCC is defined as a highly flowable, yet stable concrete that can spread readily into place and fill the formwork without any consolidation and without undergoing any significant segregation.

Reference [16] evaluated fresh and hardened properties of self-compacting concrete, where they found out that, rheological properties of conventional and self-compacting concrete are quite different and that water-cement ratio has significant effect on the strength properties of self-compacting concrete.

Prior to designing a mix for SCC an understanding is needed of the properties required for self-compaction and how this can be optimized utilizing materials readily available [6]. The dosage of the superplasticizer and viscosity modifying admixtures (VMA) is an important parameter, which influences the rheological properties of SCC. Many research works carried out in this area have proved that the role of chemical admixtures is inevitable in achieving good rheological properties of SCC [8].

Corn-cob ash has been proven to be a good substitute of cement by different researchers up to a percentage of 10% [1]; while [19] investigated effects of admixtures on the properties of corn cob ash cement concrete and they concluded that admixtures generally improve the workability of corn cob ash cement concrete and the greatest effect was caused by plasticizer which improves the flow properties of the mix by dispersing the cement particles and breaking up cement agglomerate and the incorporation of admixtures in corn cob ash cement concrete generally increases its compressive strength at all ages irrespective of the type used.

In view of the above reasons, cement partially replaced by corn-cob ash in the presence of superplasticizer aimed at achieving desirable rheological properties of corn-cob ash in a self-compacting concrete is an emerging trend in concrete technology.

2. Materials and Methods

The materials used for this research were Corn cob ash(Fly ash), Portland cement conforming to ASTM type 1, Sand (Fine aggregate), Granite (Coarse aggregate), Complast SP430 (Plasticizer) and clean and deleterious-free water. The corn-cobs were dried and later burnt in a furnace at temperature of 700^{o}C for 3 hours to obtain the ash, which was later subjected to sieve analysis to determine the particle size distribution and the amount passing 75µm sieve for the concrete mix. In order to reveal its composition, the analysis of the CCA and the mixed concrete design are conducted at the Concrete laboratory of the Department of Civil Engineering, Federal Polytechnic, Ado-Ekiti. The mix ratio used was 1:2:4 at different nominal replacement of OPC with CCA and water cement ratio of 0.5 by weight. The replacement levels of 0% to 30% by weight of CCA

Portland cement was partially replaced by Corn Cob Ash (CCA) in a mix of 1:2:4 to determine the workability of the concrete a self-compacting concrete, where Complast SP430 was also used at a percentage of 0% -3%

maximum. Self-compacting tests such as, fillingability (Slump flow) fillingability (V-funnel) passingability (U-box) and segregation potential (penetration test) were carried out including the determination of compressive strength for 7days, 21 days and 28days curing days at different mix proportions. These were carried out according to Ready *Mixed Concrete Association of Ontario standards and specifications (RMCAO) and European Federation of National Associations Representing for Concrete (EFNARC).*

3. Results and Discussion

Chemical Analysis of Corn cob Ash (CCA)

Chemical analysis was carried out on samples of CCA and ordinary Portland cement (OPC) to reveal and compare their composition, and the result shown in table 1. The percentage composition of the constituent compounds in the CCA is compared to that of typical ordinary Portland cement (OPC). The results show that CCA contains most of the compounds known to have binding properties necessary for concrete work. The percentage composition of CaO and SO_3^{2-} found in the CCA was found to be less than that in the OPC. The total percentage of iron oxide (Fe_2O_3) silicon dioxide (SiO_2) and aluminum oxide (Al_2O_3) is found to be more than the minimum of 70% specified for pozzolanas by ASTM C618 (American Society for Testing and Material). However, the percentage content of magnesium oxide was found to be much higher than the minimum recommended

Table 1: Chemical composition of CCA and OPC

Constituents	**Percentage (%) (CCA)**	**Percentage (%) (OPC)**
(SiO_2)	56.39	22.0
(Al_2O_3)	17.57	5.02
(Fe_2O_3)	9.07	4.65
(CaO)	11.47	62
(MgO)	0.98	2.06
($SO_3^{2-)}$	0.55	1.43
(K_2O)	1.98	0.4
(Na_2O)	1.91	0.19

Particle Size Distribution

Sieve analysis was carried out on 300mgrams of river sand sample. The fine aggregate passed through 5mm sieve as recommended. Before the sand was used it was oven-dried to remove the moisture content so that it will not increase the water content in the concrete mix and the results shown in table 2 and 3. The results revealed the sand sample was well graded falling into zone 2 near border of zone 1, which is very appropriate for concrete work in accordance with British Standards Institutions (BS) test sieves.

Table 2: Particle Size Distribution of Fine Aggregate

Sieve size	Weight retained {g}	Amount retained {%}	Amount passed {%}
9.50mm	**0**	**0**	**100**
4.75mm	**9.0**	**1.8**	**98.2**
2.36mm	**17.8**	**3.6**	**94.6**
1.18mm	**55.5**	**11.1**	**83.5**
600microns	**129.8**	**26.0**	**57.5**
425microns	**71.6**	**14.3**	**43.2**
300microns	**100.2**	**20.0**	**23.2**
150microns	**93.6**	**18.7**	**4.5**
75microns	**10.1**	**2.0**	**2.5**

Table 3: Particle Size of Coarse Aggregate

Sieve size {mm}	**Weight retained {g}**	**Amount retained {%}**	**Amount passed {%}**
25	**0**	**0**	**100**
20	**68.2**	**6.8**	**93.2**
12.5	**345.1**	**34.5**	**58.7**
9.5	**257.1**	**25.7**	**33.0**
4.75	**260.2**	**26.0**	**7.0**

Specific Gravity

The specify gravity test conducted on the materials revealed the specific gravity of CCA as 2.27. This value is less than the value for cement, which is 3.12; however, it falls within the recommended range of 1.9 and 2.4 for pulverized fuel ashes stipulated in ASTM C-218. It was also found out that the specific gravity of corncob ash, sand and granite was found to be 0.9, 2.65 and 2.75 respectively, which are very close to the values obtained in [6].

Absorption of aggregates

The absorption test conducted on the fine and coarse aggregates are 1.10% and 1.8% respectively. The result also conforms to the ASTM C-217.

Compressive Strength Test

Compressive strength test was carried out to determine the strength of the concrete at various ages. The concrete was placed in a curing tank filled with water and left to cure for 7, 21 and 28 days and a total of 100 specimens for percentage replacement of cement of 0%-30%and 0%-3%, the compressive strength of each concrete cubes was found, as shown in table 4. Table 4 below showed the summary of the compressive strengths at different curing days for each mix, while Figureures 1-3, further illustrate the inter-relationship between each percentage of cement replacement with CCA against the compressive strength for different curing days. The results indicate that maximum compressive strength of 9.04kN/mm^2, at 7 days curing occurred at a mix of 0%SP430 30%CCA, while that of 21 days occurred at a mix of 3%SP430 30%CCA having a value of 12.00 N/mm^2 and that of 28 days showed maximum compressive strength to be 20.37N/mm^2 at 2%SP430 30%. . The failure load were recorded and the compressive strength of each concrete cubes was found, as shown in table 4. Table 4 below showed the summary of the compressive strengths at different curing days for each mix, while Figureures 1-3,

Table 4: Summary of compressive strength

COMPRESSIVE STRENGTH N/mm²	CCA CONTENT IN %	COMPRESSIVE STRENGTH N/mm²	CCA CONTENT IN %	COMPRESSIVE STRENGTH N/mm²	CCA CONTENT IN %
7 DAYS		**21 DAYS**		**28 DAYS**	
0% SP430		**0% SP430**		**0% SP430**	
8.3	0	10.59	0	17.78	0
8.74	10	10.67	10	17.70	10
8.67	20	10.74	20	17.11	20
9.04	30	10.89	30	18.44	30
1% SP430		**1% SP430**		**1% SP430**	
8.44	0	10.59	0	17.11	0
7.99	10	11.11	10	17.19	10
8.37	20	10.66	20	18.44	20
8.29	30	11.18	30	19.33	30
2% SP430		**2% SP430**		**2% SP430**	
8	0	10.89	0	17.56	0
8.37	10	10.89	10	17.56	10
8.52	20	11.11	20	18.29	20
8.67	30	11.56	30	20.37	30
3% SP430		**3% SP430**		**3% SP430**	
8.37	0	10.74	0	17.4	0
8.57	10	10.07	10	17.56	10
8.59	20	11.11	20	18.89	20
8.89	30	12.00	30	19.62	30

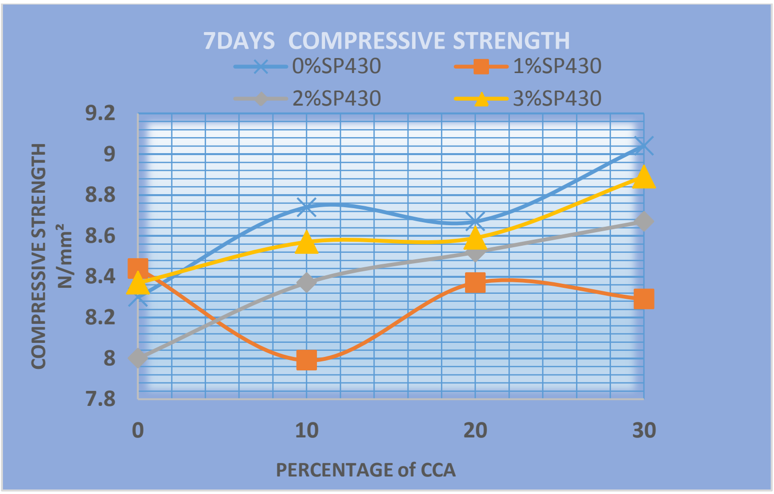

Figure 1: 7 DAYS COMPRESSIVE STRENGTH

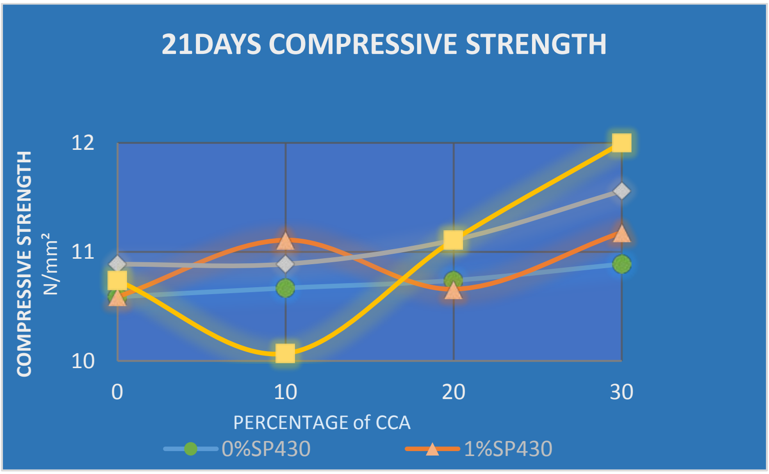

Figure 2: 21 DAYS COMPRESSIVE STRENGTH

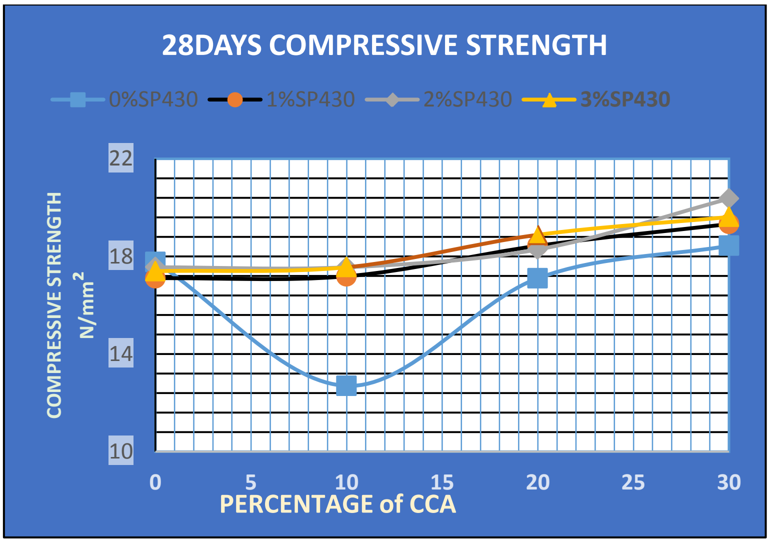

Figure 3: 28 DAYS COMPRESSIVE STRENGTH

SCC Evaluation Tests

Self-compacting tests such as, fillingability (Slump flow) fillingability (V-funnel) passingability (U-box) and segregation potential (penetration test), as shown in table 5 were conducted. These tests were conducted according to *European Federation of National Associations Representing for Concrete. (EFNARC)*

The result showed that slump value for 0%SP430, 0%CCA, 0%SP430 10%CCA, 0%SP430 20%CCA and 0%SP430 30%CCA are 160mm, 160mm, 160mm and 160mm respectively, these results were very low compared with RMACO specification of (500-800)mm range. However at a mix of 1%SP430 0%CCA to 3%SP430 30%CCA, there is a significant improvement in the slump value which can clearly be derived from the addition of Complast SP430 admixture. The result got from these mixes all fell within the range of specification, also the passing ability, flowability and segregation potential tests carried out on 0%SP430 0%CCA, 0%SP430 10%CCA, 0%SP430 20%CCA and 0%SP430 30%CCA all have no result except for 0%SP430 30%CCA having passing-ability and flowability of 30 secs. and 3mm respectively, whereas there is an improvement on the same tests in other mixes from 1%SP430 0%CCA to3%SP430 30%CCA, as shown from the table 4.

This is also the resultant effect of the Complast SP430 plasticizer admixture added to the mixes. Also, all the mixes having 0%SP430 passed the recommendation for passing ability test except 0%SP430 30%CCA having 30 secs, in addition all the mixes having 0%SP430 passed the recommendation for passingability and segregation potential tests. EFNARC/

Table 5: SELF-COMPACTING CONCRETE EVALUATION TEST

TESTS	CCA CONTENT (%)															
	0				10				20				30			
	COMPLAST SP430 CONTENT (%)															
	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3
SLUMP (mm)	160	660	720	750	160	663	720	750	160	669	726	753	160	720	730	755
V-FUNNEL(secs)	0	11	9	6	0	11	9	6	0	10	8	6	30	10	8	6
U-BOX(mm)	0	7	22	28.5	0	9	23	28.5	0	13	22.7	29	3	15	22.7	28.5
PENETRATION TEST(mm)	0	2	3	5	0	2	3.3	5	0	2.2	3.5	6	0	2.2	3.7	6.2

4. Conclusion

The rheology and strength properties of corn-cob ash blended cement in self-compacting concrete as evaluated in this research indicates that CCA is suitable to be used as admixture in producing a workable self-compacting concrete. The influence of plasticizer over concrete mix strength most especially the self compactability properties were further revealed in this research, where it has been clearly shown that when there's no presence of plasticizer in a corn cob ash mix, the self-compacting properties are drastically reduced as evident from the result presented in table 5. Moreover, the mix proportion that could give proper and maximum compressive strength at different curing days most especially 28 days has been established in this research to be 20.37N/mm² at a mix of 2%SP430 30%CCA. This is therefore the prescribed mix at which corncob ash will perform satisfactorily.

5. Recommendation

- The prescribed mix in this research should be subjected to further evaluation in diverse environmental conditions.
- Economic viability of this mix if evaluated would be of value.

References

[1] Adesanya D.A., Raheem A.A. 2009: Development of Corn Cob Ash Blended Cement, Construction and Building Materials, (Vol. 23, pp.347-352).

[2] American Standard for Testing Materials, Specification for fly ash and raw or calcium natural pozzolana for use as a mineral admixture in Portland cement concrete. ASTMC 2005, 618-78.

[3] American Society for Testing and Materials, Specifications for pozzolanas. ASTM International, USA, ASTM C618,1978

[4] Dwivedia, V.N. et al"“A New Pozzolanic Material for Cement Industry: Bamboo Leaf Ash,” International Journal of Physical Sciences, vol. 1, no. 3, pp. 106-111, 2006.

[5] European Federation of National Associations Representing for Concrete. (EFNARC): Specifications and Guidelines for Self-Compacting Conctete. 2002. www.efnarc.org.

[6] John N, et al, Advanced concrete Technology Processes, first edition (2003), England: Butterworth Heinemann, Elsevier Limited, 2003.

[7] Khayat, K.H., Ghezal, A., Hadriche, M.S. (1999: Factorial design models for proportioning self-consolidating concrete, Materials and Structures, **32**, 679–686.

[8] Kou, S.C. and Poon, C.S. (2009) Properties of Self-Compacting Concrete Prepared with Coarse and Fine Recycled Concrete Aggregates. Cement and Concrete Composites, **31**, 622-627. http://dx.doi.org/10.1016/j.cemconcomp.2009.06.005

[9] Li, B., Wang, J. and Zhou, M. (2009) Effect of Limestone Fines Content in Manufactured Sand on Durability of Lowand High-Strength Concretes. Construction and Building Materials, **23**, 2846 2850. http://dx.doi.org/10.1016/j.conbuildmat.2009.02.033

[10] Mehta, P. K. (1997). Properties of blended cements made with sawdust ash. ACI Journal Proceedings, 74:440- 442.

[11] Nair, D.G., et al, (2006) “Reactive Pozzolanas from Rice Husk Ash: An Alternative to Cement for Rural Housing.” Cement and Concrete Research, V. 36, pp. 1062-1071.

[12] Nimityongskul, P., et al. (1995). Use of coconut husk Ash, corn cob ash and peanut shell ash as cement replacement. Journal of Ferro cement, 25(1): 35-44.

[13] Nwofor T.C., et al, Stability of groundnut shell ash (GSA)/ordinary Portland cement (OPC) concrete in Nigeria, Advances in Applied Science Research, 2012 3(4):2283-2287, Available online at www.pelagiaresearchlibrary.com.

[14] Shetty M.S., Concrete Technology Theory and Practice, revised multi-colour edition. 2005, India: S.CHAND & COMPANY Ltd India.

[15] Okamura H. et al., (2003): “Applications of Self Compacting Concrete in Japan,” Proceedings of the 3rd International RILEM Symposium on Self-Compacting.

[16] Olafusi, O.S., Adewuyi, A.P., Otunla, A.I. and Babalola, A.O. (2015): Evaluation of Fresh and Hardened Properties of Self-Compacting Concrete. Open Journal of Civil Engineering, **5**, 1-7. http://dx.doi.org/10.4236/ojce.2015.51001

[17] Olutoge F.A., et al, “Use of Coconut Husk Ash, Corn Cob Ash and Peanut Shell Ash as Cement Replacement,” Journal of Ferrocement, vol. 25, no. 1, pp. 35-44, 1995.

[18] Raheem, A. A. et al, (2011), “A study of thermal conductivity of corn cob ash blended cement mortar”, The Pacific Journal of Science and Technology, Vol.12 No. 2, pp. 106 – 111

[19] Raheem, A. A.; et al, (2010), “Effects of admixtures on the properties of Corn-Cob ash cement concrete”, Leonardo Electronic Journal of Practices and Technologies, Vol. 16, pp.13 – 20.

[20] Singh, V. D. &Rai., R. (2000). Hydration of bagasse ash-blended Portland cement. Cem. Concr. Res.30: 1485-1488.

[21] Raju G.U, et al, Mechanical and physical characterization of agricultural waste reinforced polymer composites, J.Mater. Environ. Sci. 3 (5) (2012) 907-916, ISSN: 2028-2508, pp 907-914.

[22] Sakr, K. (2006). Effects of Silica Fume and Rice Husk Ash on the Properties of Heavy Weight Concrete. Journal of Materials in Civil Engineering, 18(3): 367-376.